UTILIZATION OF INLAND SWAMPS AND MARSHES FOR AQUACULTURE

by

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Abstract

The ecology of swamp areas and its relevance to fish production in India is considered in detail. The utilization of these swamp areas for fish culture, especially the raising of air-breathing fishes is discussed.

CONTENTS

1. NATURE OF THE ENVIRONMENT

Certain representative swamp ecosystems have been studied and it has been possible to characterize this environment (Table 1)

Rzoska (1974) described the upper Nile swamps by means of various environmental parameters. Welcomme (1975) has presented an excellent 'habitat synopsis' of the floodplains of Africa giving special reference to the vast swampy areas and with a consideration of their fisheries. Dehadrai *et al.*, (1976) studied derelict swampy waters as a habitat of air-breathing fishes in north-east and south India. It is estimated that about 0.6 million hm^2 of derelict, swampy, weed infested water area exists in India. Javaid (1976) reported approximately 0.08 million hm^2 of weed infested waters in Pakistan.

The gradual process of dereliction of inland water bodies may be natural or due to man's activities. Rapid evaporation, siltation and organic decay can produce biologically unproductive waters which are neglected by man and their reclamation postponed. Invasion of these shallow waters by floating, emergent and submerged aquatic weeds further precludes their usefulness as a healthy aquatic habitat. Free floating and emergent weeds are extensive in Indian swamps (Philipose *et al.*, 1970) with the eastern zone having the maximum incidence of 40-70 percent as compared to 20-25 percent for the rest of India. The trophic potential of swampy waters is low, with the profusely growing macrophytes as primary producers at the cost of other useful primary and secondary links of the food chain.

The flood control measures applied to rivers in India and Africa prevent the annual replenishment of the water of large numbers of functional ponds and lakes, thus exposing them to the inevitable process of dereliction. In north-east and southern India there are records of many functional water bodies having become totally derelict swamps. Many swamps retain a connection with rivers, and replenish their water (including fish) every year, as in north-east India and the floodplains of Africa (Guiana). Other swamps are completely enclosed and stagnant as in central and southern India, the Paraguayan Chaco and Uganda. Under these conditions the normal metabolic cycle is essentially disrupted by the presence of a dense growth of vegetation. The shading effect of the vegetation mat adversely affects photosynthesis, nutrient circulation and the balance of metabolic gases.

The thick vegetation provides a good environment for a variety of aquatic insects which abound in swamps and gastropods and a large number of annelids are also common (David *et al.*, 1974). Although considerable quantities of fish food material including micro- and macrophytes, bottom fauna, insects and decaying organic matter may be available in derelict and swampy waters, their fish fauna is limited. This is mainly attributed to the adverse physico-chemical conditions of these waters where fast growing, non predacious fishes with a short food cycle are not able to thrive and are susceptible to various diseases. However, certain slow growing hardy fishes with a low sensitivity to harmful gases and having carnivorous food habits as well as those subsisting on detritus, survive in such environments. Air-breathing teleosts appear to be best adapted with their predaceous food habits, accessory aerial respiration and other biological and physiological adaptations.

2. UTILIZATION OF SWAMPY, DERELICT WATERS

Management of these aquatic resources for fisheries requires long-term planning. Welcomme (1975) has already projected an effective strategy for African floodplains and has described the unique case of Queme valley as an example of an integrated development for the full utilization of its productive potential by a programme of alternating fisheries, agriculture and cattle raising, etc.

2.1 Reclamation of swamps for carp culture

The conversion of swamps for controlled fish production was considered in India as early as the Second Five-Year Plan. Several long-term loans and subsidies were sanctioned to State Governments for this programme.

The conversion of swamps into carp culture farms requires considerable planning effort depending upon the type of operation necessary such as deweeding, desilting, construction of embankments, fertilization, etc. In addition to the heavy initial cost of reclamation and the recurring cost of the maintenance of dykes and the control of vegetation, the returns were comparatively meagre. Capital costs could only be recovered after a period of more than 15 years.

2.2 The culture of air-breathing fishes

Species selected for fish culture in the swamp environment had to survive low oxygen and high carbon dioxide concentrations. Air-breathing fishes of tropical swamps should be ideally adapted for culture systems with low inputs and high yields. *Clarias batrachus*, *Heteropneustes fossilis*, *Anabas testudineus*, *Ophiocephalus* spp. (murrel), *Notopterus*, constitute a natural fauna of Indian swamps. The present day catch of air-breathing fishes in India, which is 15 percent of the total marketable surplus of inland fishes, results from an unorganized capture fishery of wild waters. In the capture fisheries of African floodplain swamps, the air-breathing fishes in India are highly prized for their high protein, high iron and low fat contents (compared to the carps) and have a sizable specific market demand in India.

In India, under an All India Coordinated Research Project sponsored by the Indian Council of Agricultural Research at the Central Inland Fisheries Research Institute, Barrackpore, a controlled culture system of air-breathing fishes has been developed. In addition to studies on their fishery biology, the commercially important species have been induced to breed by hypophysation using carp pituitary. Hypophysation doses have been standardized and techniques to rear their cannibalistic spawn to stockable size have been developed.

Areas in north-east and southern India have been surveyed for the procurement of naturally occurring seed of air-breathing fishes. With the availability of stocking material, the production potential of *Clarias*, *Heteropneustes*, murrels and *Anabas* per unit water area through short duration culture, have been demonstrated.

The excellent response of these fishes to supplementary feeding has made their intensive culture possible. In addition to the encouraging growth of *Clarias*, *Heteropneustes* and *Anabas* fed with oil cake+rice bran mixture, the catfish *Clarias* accepted cheaply available dried marine trash fish with conversion ratio of 1.5:1, comparable to that in the case of murrels with 1.7:1. Better food conversion and faster growth in *Clarias* and murrels were recorded when cultured in shallow waters as it avoided the energy loss due to their inevitable vertical trips for aerial respiration.

Clarias is cultured abundantly in Thailand and other Far East countries.

2.2.1 Cage culture

Unmanageable, weed infested, vast water bodies cannot be used directly for open stocking. An effective answer to this problem is the culture of air-breathing fishes in convenient size cages made of available split bamboo mats kept partially emersed on floating rafts. In terms of fish production per unit area of water, no other culture technique can surpass cage culture. Cage culture experiments in Assam State, India, yielded a gross and net production of *Ophicephalus punctatus* and *Heteropneustes fossilis* of 5 175/3 175 gm per square metre in 200 days and 4 832/3 256 gm per square metre in 90 days respectively. It should be possible to achieve a target of 10 kg per square metre area of cage per year.

2.2.2 Air-breathing fish culture with aquatic cash crops

A large number of fishery waters in north-eastern and central India having become shallow, derelict and swampy with a heavy silt deposition are now completely unusable for conventional fisheries. Many such waters in North Bihar, Assam and Madhya Pradesh have been brought into commercial use by cultivating aquatic cash crops, such as 'Makhana' (*Euryale ferox*) and 'Singhara' (*Trapa bispinosa*). By adapting the production time cycle of 'Makhana' and 'Singhara' cultivation, and incorporating the air-breathing fish culture cycle, the income from such ecologically derelict waters could be immediately enhanced. The planting of aquatic crops provides protection from poaching for the stocked fish.

2.2.3 Open stocking

Derelict water bodies of manageable sizes could also be utilized for mixed culture of compatible species of air-breathing fishes, such as *Clarias batrachus* and *Anabas testudineus* or *C. batrachus* and *Ophicephalus* spp. or *C. batrachus*, *Heteropneustes fossilis* and *A. testudineus*. In addition, the monoculture of murrels and *Clarias* has yielded very encouraging results. The presence of weeds, such as water hyacinth, provides protection from poaching as well as providing a substrate for a variety of insect fauna food for the fish. The respiratory adaptations of these fishes permit a very high stocking density (Table 2).

The use of trawler trash or the low grade dried marine trash fish, which are cheaply available in the maritime states, provides excellent scope for intensive as well as extensive culture of air-breathing fishes in these regions. However, in inland states the air-breathing catfishes and other air-breathing species which possess digestive enzyme systems responding to carbohydrate diets can be easily cultured on feeds consisting of agricultural by-products such as oil cakes and brans.

The performance of *C. batrachus*, even when cultured in sewage-fed ponds with BOD values ranging between 26 and 88 ppm, was remarkable and registered an average net gain in weight of 162.5 gm in 100 days without supplementary feeding.

In addition to their aerial respiratory habits, the *Clarias* sp. and *Heteropneustes* sp. have an inherent tolerance to heavy metal and pesticide toxicity compared to fish even as tolerant as *Tilapia mossambica*.

Considering the abundant availability of air-breathing fishes in swampy and derelict waters; their high commercial demand; their amenability to controlled culture; the possibilities of high yields at heavy stocking densities; the requirements of a low input and relatively simple management techniques; suggest that they are the most suitable fish species for utilizing swampy derelict waters of the tropical and subtropical world. A viable culture system of these fishes has already been demonstrated in India. Attempts must be made to convert the traditional but meagre capture fishery from wild waters to a scientific controlled culture system.

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TABLE 1

ENVIRONMENTAL FEATURES OF SOME REPRESENTATIVE SWAMPS OF THE TROPICAL WORLD

Name and locality of the swamp	*Temp. °C*	*pH*	*Dissolved oxygen (mg 1-1)*	*Free CO_2 (mg 1-1)*	*Total alkalinity (10-4N)*	*Conductivity (cm-1 at 20°C)*	*Investigator*
NILE SWAMP							
Swamp rivers							
Bahr el Gabel ...	22–28	6.8–8.2	0.66–6.2	2.80–18	–	112–550	Modified after Rzoska (1974)
Bahr el Ghazal ...	22–28	6.4–8.4	1.3–8.0	–	–	40–370	
Bahr el Sobat ...	22–28	6.8–7.8	3.4–6.2	–	15.2–50.0	110–280	
Bahr el Zeraf ...	22–28	7.5–8.0	2.2–5.9	–	92.0–116·0	245–370	
Standing waters ...							
Shambe Lagoon ...	22–28	6.95–8.0	2.4–6.0	–	31.7	–	Modified after Rozska (1974)
Lagoon R.P. 12 ...	22–28	7.25–8.4	6.1–10.2	–	21.4–31.4	200–250	
Lake Ambadi ...	22–28	6.4–7.2	8.0	–	25.4	40–55	
Khor Perboi ...	22–28	–	1.8–7.15	–	–	–	
Khor Atar ...	22–28	8.0–8.6	6.88–11.5	–	29.	–	
GUINEAN SWAMPS							
Grass swamp A ...	26–29.5	4.42–4.5	0.22–1.24	8.37 – 9.18	Absent	–	Carter (1935a)
Other swamps ...	26–29.5	4.53	0.65	13.48	Absent	–	
Pool B	26–29.5	4.07–4.15	0.60– 1.45	5.02	Absent	–	
EAST AFRICAN SWAMPS							
Lake Naivasha ... (Papyrus swamp)	25	7.8	2.51	–	–	–	Beadle (1932)
Kazinga Channel ... (Papyrus swamp)	26.7	5.9	nil Traces	–	7.5	–	
Kitoma (Papyrus swamp)	–	6.7	nil	–	71.6	–	
INDIAN SWAMPS							
Polluted swamp ...	19–33	8.0–9.6	6.45– 8.2	16.4–20	148 ppm	–	Dehadrai *et al* (MS)
Semi-senescent swamp	19–33	8.0–8.6	0.6– 3.2	20	143.4 ppm	–	
Senescent swamp ...	30.1–32.5	8.0	1.5 – 2.65	12	94–162ppm	–	

TABLE 2

PRODUCTION POTENTIALS OF AIR-BREATHING FISHES IN DERELICT WATERS IN INDIA

Species	*Stocking rate per hm²*	*Place and water area*	*Type and rate of supplementary feed used per hm²*	*Net production per hm² actual production*	*Remarks*
BIHAR CENTRE					
batrachus *A. testudineus*	70 000	Darbhanga 0.03	Nil	1 200 kg hm-2 per 7 months 35 kg (actual)	Another experiment of similar rate with marginal 'makhana' plantation indicated additional production of 5 kg per 0.04 hm2 of makhana seeds.
H. fossilis *A. testudineus*	40 000	Darbhanga 0.04	Nil	524 kg hm2 per 10 months 20.9 kg (actual)	with 'makhana' cultivation
KARNATAKA CENTRE					
O. marulius	10 000	Bhadra 0.03	Dried marine trash fish @ Re. 1/- per kg 4 000 kg in 8 months	3 200 kg hm2 per 8 months 96 kg(actual)	with higher stocking density of 20 000 hm2 a very high annual production is envisaged
ASSAM CENTRE					
C. batrachus *A. testudineus*	8 000 35 000	Gauhati	Dried silk worm pupae oil cake & rice bran	916 kg hm-2 per 11 months	At the total cost of Rs. 1360/- with average growth of 150 gm *Clarias* and 60 gm *Anabas* Retrieval of *Anabas* was poor.
WEST BENGAL CENTRE					
C. batrachus	40 000	Kalyani 0.04	Dried marine trash fish @ 40 kg hm-2 day-1 at the cost of Rs. 70/- per quantal.	Assessed production 5500 kg hm-2 per 5 months 220 kg (actual)	About 500% profit over the material inputs of feed and fingerling has been projected. The stock was stolen in July and actual harvesting was @ 2 000 kg hm-2 per 6 months.
A. testudineus	60 000	Kalyani 0.03 hm2	Rice bran, ground nut oil cake and fish meal (1:1:1) 40 kg hm-2 day-1	Recorded production 1 800 kg hm-2 per 70 days	Marketable size being 40-50 gms, the controlled production is significant
C. batrachus	2 000	Amgachia	Ground nut oil cake rice palish dried marine trash (1:1:3) 40 kg hm-2 day-1	1 200 kg hm-2 per 4½ months 60 kg (actual)	As an additional component of composite fish culture 80% *Clarias* could be harvested along with 126 kg of carps.
C. Batrachus	2 000	Khardah Municipality Sewage treatment plant	Nil	Assessed production 800 kg hm-2 month-1	In a sewage fed pond, along with Tilapia, 20 000 per hm-2 BOD ranged between 26-88 ppm.
C. batrachus *T. mossambica*	3 000+ 26 000	0.076	Nil	Estimated production 576 kg hm-2 per 100 days per 100 days 66 kg + 175.3 kg (actual)	Experiment continued with encouraging growth rate.